Early Plant Introductions in Hawai'i

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INTRODUCTION

When Capt. James Cook arrived in Hawai'i in 1778 the flora of the islands consisted of about 2700 native species and infraspecific taxa and about 30 exotic species.[1] In the ensuing 200 years, at least 5000 species and varieties have been introduced into the Islands. The first exotic (i.e., non-native) plants to reach Hawai'i were those which the first colonizers brought from their ancestral land, and after the European discovery of Hawai'i the introduction of foreign plants increased dramatically.

Plant introductions into Hawai'i can be conveniently divided into two periods, Polynesian and European. Verification of Polynesian introduction of certain species is difficult because of the lack of written language. Hawai'i became a major port of call after Cook's discovery, and botanical collections and observations made by scientific expeditions as well as more casual accounts left by visitors and early residents are important sources of information regarding the flora of the Islands at that time.

For the purpose of this paper the "early European period" is defined as the period between Cook's discovery in 1778 to the arrival of the United States Exploring Expedition in 1840. The systematic survey conducted by the expedition provided a vast amount of new scientific information about Hawai'i which should be treated separately. The period under consideration here includes the lifetime of Francisco de Paula Marin who was responsible for the introduction of numerous plants. He arrived in 1793 or 1794 and died in 1837, the year in which HMS *Sulfur* arrived in the Islands.

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Aboard the *Sulfur* was the botanist George Barclay whose collections added much to our knowledge of the Hawaiian flora. Barclay and the *Sulfur* returned to Hawai'i in 1839, and in the following year the great United States Exploring Expedition was launched. Thus, 1839 was selected to terminate the European period of plant introduction in this paper.

POLYNESIAN PERIOD *(See Table 1)*

Ethnobotanical problems cannot be solved within the confines of any single discipline but may require research in such fields as anthropology, geography, archaeology, linguistics, and botany, as well as ethnobotany. It is not within the scope of this study to examine the ethnobotany of those plants which are assumed to have been brought to Hawai'i by the migrating Polynesians. If Polynesian colonization was deliberate, then the canoes which brought the early voyagers were probably stocked with useful plants and animals. These may not have all come at once but gradually on successive voyages.[2] Some controversy exists as to whether certain species are actually native or aboriginal introductions. The evidence and arguments are often complex and are not relevant here. The native/introduced status of the plants follow that of St. John.[3]

Handy and Handy[4] assert that most of the important plants of the Hawaiian horticultural complex are associated with native tradition associated with their introduction. The plants associated with certain gods of the Polynesian pantheon—Kāne, Lono, Kanaloa, and Kū—can be traced back to the culture in which they originated. For instance, taro *(Colocasia esculenta)*, sugar cane *(Saccharum officinarum)*, and bamboo *(Schizostachyum glaucifolium)* are associated with Kāne, and because of his supreme place in religion these plants are thought to have come in the first wave of migration. It is believed that people associated with the god Kanaloa came next and brought with them the banana (*Musa* sp.). It is also very likely that this second wave came from the Society Islands. Other plants are associated with the remaining two gods. The sweet potato *(Ipomoea batatas)* and gourd *(Lagenaria siceraria)* are associated with Lono, and the coconut *(Cocos nucifera)* and breadfruit *(Artocarpus altilis)* with Kū. Legend and folklore speak of most of the other plants which were important in the Hawaiian culture, but they are not associated with these four major deities.

EUROPEAN PERIOD *(See Table 2)*

Capt. James Cook, while on his third voyage to the Pacific, is

credited with the European discovery of Hawai'i in January, 1778. His expedition visited the Islands twice during that voyage, and the observations and collections made are the earliest documentation of the Hawaiian vegetation. The designated naturalist on the expedition was William Anderson, but he apparently did very little botanizing and died in the North Pacific before the expedition made its second visit to Hawai'i. It was on the second visit that the first plant collections and observations were made by young David Nelson, a gunner and apprentice botanist aboard the *Discovery,* sister ship of Cook's *Resolution.* Ewan[5] incorrectly stated that Nelson had two weeks to botanize during the two-month stay at Kealakekua Bay, Hawai'i. In fact, probably all of Nelson's botanizing was made during an unsuccessful ascent of Mauna Loa between 26 and 30 January 1779.[6] Nelson collected at least 136 herbarium specimens and compiled a list of 31 plants which he turned over to Capt. Clerke, master of the *Discovery.* The list, annotated with modern nomenclature, is found in Ewan,[7] and an enumeration of his herbarium specimens is found in St. John.[8]

Within 40 years after its discovery, Hawai'i became an important port of call in the Pacific. Traders, whalers, scientific, and commercial expeditions all stopped for provisions, rest, and recuperation as well as for scientific exploration. In 1822 alone, no fewer than 60 whalers called at various Hawaiian ports, and in the last four years of the decade, arrivals at Honolulu averaged more than 140 annually.[9] The increase in the number of visiting ships resulted in a greater demand for not only domestic but for foreign goods as well. The import of foreign commodities increased accordingly as did the opportunities for plant introductions.

The scientific expeditions which visited the Hawaiian Islands during this period usually included naturalists or botanists, and their journals and collections are the most important sources of vegetational information. The journals of seafarers as well as those of independent travelers and collectors also added much to our knowledge of the vegetation. In addition, some early accounts of the introduced flora can be found in the writings of residents, especially those who were amateur naturalists. The history of botanical exploration in Hawai'i is summarized in Kay.[10]

Any investigation concerning the introduction of plants in Hawai'i must include the activities of Francisco de Paula Marin. During his approximately 44 years of residence in the Islands he was responsible for the introduction of numerous plants. Marin may have made trips

to North America, but these are not verified, and it appears that very few plants could have actually been brought by him. His letters and journal entries indicate that most of the plants were sent by friends in California and Mexico or were given to him by visitors.[11] Marin was a man of many talents, and his ability as a horticulturist was among his finest. His gardens attracted the attention of tourists and botanists alike, and it is fortunate that these visitors often wrote of his plants because the diary which he kept, although a valuable source of information, is incomplete.

Herbarium collections offer undeniable evidence of the presence of plants in an area, and the collections by botanists on the early scientific expeditions are extremely valuable records. Collection lists for Lay and Collie,[12] Menzies,[13] Macrae,[14] Nelson,[15] and Barclay[16] were useful, but unfortunately no list for other botanists could be located. Figure 1 lists chronologically the expeditions, collectors, visitors and residents whose records have been important contributions to Hawaiian botany before 1840.

RESULTS AND DISCUSSION

Fourteen species were believed to be of Polynesian introduction by Handy and Handy.[17] In 1973, St. John listed 26 Polynesian introductions. A comparison of these lists reveals that ten of the species which St. John considered introduced were considered "wild" or native by Handy and Handy. These included kou *(Cordia subcordata)*, mountain apple *(Eugenia malaccensis)*, milo *(Thespesia populnea)*, kukui *(Aleurites moluccana)*, and noni *(Morinda citrifolia)*. Two species listed by St. John were not mentioned by Handy and Handy. Surprisingly, one of these is kamani *(Calophyllum inophyllum)*, a species common throughout the South Pacific and tropical Asia where it is highly esteemed for its oil, wood, and medicinal properties.[18] It is mentioned in old Hawaiian chants, and its importance in the Hawaiian culture is described by Neal[19] and Degener.[20] The other species overlooked not only by Handy and Handy but by all the early botanists and enthologists is pa'ihi *(Nasturtium sarmentosum)*. Because of its economic value as a food and a medicinal, St. John[21] believed that it has been carried by man throughout Polynesia and to Hawai'i. It is widespread throughout Oceania where it has usually been recorded as a weed near villages and in cultivated fields.

Six of the 19 non-native species recorded by David Nelson were previously thought to be post-Cook introductions.[22] These six are:

kamole *(Ludwigia octivalvis)*, indigo *(Indigofera suffruticosa)*, aramina *(Urena lobata)*, kukaepua'a *(Digitaria pruriens)*, yellow wood sorrel *(Oxalis corniculata)*, and hairy merremia *(Merremia aegyptia)*. All except indigo were common weeds in the tropical Pacific at the time and are thought to be accidental introductions.

The occurrence of indigo is an anomaly. It was an important source of dye and a common species at least in the Indo-Malayan area, but the Hawaiians never used it as a dye, nor was it found in Tahiti until after 1769. Seemann[23] noted: " . . . Not being contained in the older collections, it is probably a recent introduction to Polynesia." Because of its economic potential it is plausible that Marin would have been acquainted with it, but he made no mention of the species. Sereno Bishop, who remembered it during his childhood days in Kona in the 1830s, was the first after Nelson to record the plant.[24] If the migrating Polynesians were not familiar with its properties they would have had no reason to carry it with them on their migrations but might have brought it accidentally. On the other hand, if the Spanish were in Hawai'i during the 16th century this plant might represent a part of their legacy.

The 32 species now believed to have been brought to Hawai'i by the migrating Polynesians are listed in Table 1. Twenty-two sources were located which document the occurrence of these aboriginal introductions. In four instances, two or more sources stem from the same voyage—Cook, Nelson, and Ledyard (1779), Vancouver and Menzies (1792–94), Kotzebue and Chamisso (1816–17), and Bloxam and Macrae (1825).

Of these species, 'ape *(Alocasia macrorrhiza)*, pi'ia *(Dioscoria pentaphylla)*, and pa'ihi were not seen or collected again until after 1839. Others, for instance kamani, kukaepua'a, milo, aramina, hairy merremia, indigo, 'ōlena *(Curcuma longa)*, pi'oi *(Dioscoria bulbifera)*, and 'awapuhi *(Zingiber zerumbet)*, were seldom documented. On the other hand, some species such as kukui, breadfruit, coconut, sweet potato, banana, taro, sugar cane, and wauke *(Broussonetia paprifera)* were often collected or observed. All of these are large species or were cultivated in extensive field systems and were frequently recorded in the journals of visitors and residents when they described the lifestyles and activities of the Hawaiian people. Moreover, voyagers who stopped in Hawai'i for provisions also made special note of the food plants which were obtained from the natives.

Records of non-Polynesian introductions also began with the arrival of Cook in 1778. Although Nelson only recorded native and

aboriginal plants, Cook in his journal stated that seeds of melons, pumpkins *(Curcubita pepo)*, and onions *(Allium cepa)* were planted on his first visit in 1778.[25] These are the first plants for which there are known introduction dates. To assure an adequate supply of provisions on subsequent visits the early voyagers often planted vegetable and crop seeds and introduced livestock to the Islands. Meares during his visits in 1788 and 1789 observed potatoes *(Solanum tuberosum)*.[26] The identification of Meares' "potato" as *S. tuberosum* is tentative since early observers also used "potato" to mean sweet potato. On his first visit to the Islands in March 1792, Vancouver introduced oranges *(Citrus sinensis)*, lemons *(C. limonia)*, almonds *(Prunus dulcis)*, some "vine plants" (grapes?), and an assortment of garden seeds. In addition, he mentioned that they received musk melons *(Cucumis melo)*. His comments also suggest that oranges and lemons may have already been in Hawai'i prior to their arrival.[27-28] Menzies, the botanist on the voyages, made the second botanical collection in Hawai'i. Most of the specimens were of native plants, but he also collected two Polynesian introductions and three exotics of post-Cook origin. The exact date of collection is not known, but Vancouver visited the Islands in 1792, 1793, and 1794, and these years document the first collection of kakalaioa *(Caesalpinia bonduc)*,[29] pukamole *(Lythrum maritimum)*,[30] and *Phaseolus addenanthus*.[31-32]

Four years later Broughton landed at Kealakekua, and during his first visit from January to February 1796 his crew planted grape vines and some vegetable seeds. Pumpkins, melons, and cabbages *(Brassica oleracea* var. *capitata)* were observed. When he returned in July of that year he found that all the vegetables except horse radishes *(Armoracia rusticana)* and cabbages had died.[33] The date of introduction of horseradish is established as 1796, but cabbages were already in Hawai'i by that time.

Knowledge of the Hawaiian flora was greatly expanded by the French botanist Charles Gaudichaud-Beaupre, the designated botanist during the world scientific expedition of the *Uranie* in 1819. Of the 20 days the *Uranie* spent in Hawaiian waters, Gaudichaud was able to spend seven on shore. During this period he collected numerous native species, many of them new to science, and made careful and detailed observations of the vegetation. His published account or the voyage established the first Hawaiian records for pakai *(Amaranthus virdis)*, balloon vine *(Cardiospermum halicacabum)*, spider flower *(Cleome spinosa)*, horseweed *(Erigeron canadensis)*, spurflower *(Plectranthus parviflorus)*, castor bean *(Ricinus communis)*, and

moon flower *(Ipomoea alba)*. He also recorded a wood sorrell *(Oxalis debilis* var. *corymbosa)* and stated that turnips *(Brassica rapa* var. *rapa)* and garlic *(Allium sativum)* grew in abundance in the shade of the breadfruit and sandalwood trees.[34] None of these three plants were ever mentioned again until after 1840.

In May, 1825, the HMS *Blonde* arrived in Honolulu with the bodies of the late king and queen of Hawai'i. Aboard were the botanist James Macrae and the naturalist Andrew Bloxam and perhaps the largest collection of plants to be introduced into Hawai'i up to that time. The observations and collections by Macrae and the observations by Bloxam were the most extensive of the period. The plants were turned over to Marin and were planted by him on 28 May and 7 July, 1925.[35] The plants brought abroad the *Blonde* were recorded by Bloxam[36] and are quoted below with my annotations in parentheses:

From England and transported on 28 May 1825:

1	*Anona cherimolia*	(*Annona cherimola* Mill.)
1	*Anona* species	
1	*Psidium pomiferum*	(*P. guajava* L.)
1	*Psidium* Chinese	
1	*Psidium* species from Maranha	
1	*Eugenia aquea*	
1	*Demacarpis longum*	(*Euphoria longana* Lam.)
4	peaches or nectarines	(*Prunus persica* (L.) Batsch.)
2	walnuts	(*Juglans regia* L.)
2	figs	(*Ficus carica* L.)
1	plum	(*Prunus* sp.)
1	apple	(*Pyrus malus* L.)
2	cherries	(*Prunus* sp.)
8	grapes	(*Vitis? vinifera* L.)

Plants from Rio de Janeiro:

7	*Myrtis virides* Lacram-to	(*Eugenia viridis* Berg.)
7	*Myrtis* species nova	
3	*Mangifera indica*	
2	*Laurus persia*	(*Persea americana* Mill.)
5	*Citrus nobilis*	(*Citrus reticulata* Blanco)
12	oranges raised from seed	(*C. sinensis* (L.) Osbeck)
2	figs	(*Ficus carica* L.)
8	*Eugenia jambos*	
30	coffee plants	(*Coffea arabica* L.)
1	*Datura arborea*	
8	grapes, Valparaiso	(*Vitis? vinifera* L.)

Besides several esculent seeds from Rio and Valparaiso, some of which have already vegetated.

Among the numerous specimens collected in 1825 by Macrae are the first documentation of ageratum *(Ageratum conyzoides)*,[37] *Amaranthus lineatus*,[38] golden beardgrass *(Chrysopogon aciculatus)*,[39] marsh cypress *(Cyperus javanicus)*,[40] sea bean *(Dioclea wilsonii)*,[41–42] and small flowered mallow *(Malva parviflora)*.[43] All are post-Cook exotics with the possible exception of the marsh cypress which may be indigenous.[44] Macrae was also the first to observe the common canna *(Canna indica)* and lima beans *(Phaseolus limensis)* in Hawai'i; he also noted that pigeon peas *(Cajanus cajan)* were given to a white resident in 1824.[45] To these first records Bloxam[46] added the calabash tree *(Crescentia cujete)*, dragon tree *(Dracaena draco)*, and pohā *(Physalis peruviana)*.

The following year George T. Lay and Alexander Collie arrived aboard the HMS *Blossom*. Their collections included six species previously unreported in Hawai'i: maple leaf goosefoot *(Chenopodium hybridum)*, morning glory *(Ipomoea purpurea)*, basketgrass *(Oplismenus hirtellus)*, goosegrass *(Eleusine indica)*, garden spurge *(Euphorbia hirta)*, and whorled marsh pennywort *(Hydrocotyle verticillata)*.[47]

In the summer of 1831 the Prussian ship *Prinzess Louise*, under the command of Capt. W. Wendt, arrived in Hawai'i. The ship's naturalist, Franz Julius Ferdinand Meyen, was a medical doctor by training and an exceptionally careful observer. Among the numerous native and cultivated plants mentioned in his journal are indigo, which he claims was brought from Batavia by a Mr. Serriere, and the first Hawaiian records of pomegranate *(Punica granatum)*, pondweed *(Potamogeton* sp.*)*, and the fresh water alga *Chara armata* var. *diaphana*.[48]

In 1837–39 HMS *Sulphur* arrived. The botanical collector, George Barclay, collected koa haole *(Leucaena leucocephala)*,[49–50] cuba jute *(Sida rhombifolia)*,[51] and kikania-lei *(Solanum aculeatissimum)*.[52] The only other voyage that established first records of post-Cook exotics was that of Kotzebue (1816–17). The botanist on that expedition was Adlebert von Chamisso, and although he made an extensive collection, this writer could not find any list of his specimens. Chamisso mentioned several plants in his report, however; among them were the common purslane *(Portulaca oleracea)*[53] and watermelon *(Citrullus lanatus)*.[54]

Other sources added little to the list of early introductions. William Ellis[55] observed the citron *(Citrus medica)*, and Sereno Bishop[56] saw the following in his childhood days in Kailua-Kona: wild mustard *(Brassica campestris)*, pride of the Barbados *(Caesalpinia*

pulcherrima), wild peppergrass *(Lepidium virginicum)*, and chinaberry *(Melia azedarach)*.

Francisco de Paula Marin resided in Hawai'i from 1793 or 1794 until his death in 1837. Although gaps in his journal indicate that he was probably away from the Islands on several occasions, this cannot be verified. It is apparent that he made at least one trip to Alaska and California and brought back plants and seeds, but nothing is mentioned in his journal. Marin became the king's financial advisor, wine-maker, a self-made physician, and Hawai'i's first gentleman farmer. His gardens were mentioned by Chamisso, Freycinet, Macrae, Meyen, and Beechey. Marin was an avid horticulturist. Most of his letters to friends and business associates in California, Mexico, and South America included requests for seeds, and visitors bringing plants to Hawai'i usually gave them to him. Nathan and Jonathan Winship, two New England sea captains keenly interested in horticulture, were instrumental in supplying Marin with many of his horticultural specimens. Vegetable and crop seeds were also given to him by Capt. Daniel Chamberlain.[57]

Entries in his journal and other sources indicate that the species planted by Marin included tamarind *(Tamarindus indica)*,[58] grapes *(Vitis? vinifera)*,[59] prickly pear cactus *(Opuntia megacantha)*,[60] apricot *(Prunus armeniaca)*,[61] olive *(Olea europea)*, and peach *(Prunus persica)*.[62] Meyen, during his explorations on O'ahu in June 1831, saw the following growing in Marin's estate near Pearl Harbor: coffee *(Coffea arabica)*, "Guatemalan cocoa" *(Theobroma cacao)*, lime *(Citrus aurantifolia)*, papaya *(Carica papaya)*, pineapple *(Ananas comosus)*, oranges, tamarind, and grapes.[63] Marin owned another parcel of land in upper Pauoa Valley in which he planted several kinds of trees. In 1857 among the large trees found in the area were mango *(Mangifera indica)*, avocado *(Persea americana)*, coffee, and oranges.[64] These were obviously part of Marin's plantings, but it cannot be assumed that he introduced them, as all four were among those which came aboard the *Blonde* and were planted by Marin. It is impossible to determine which are the *Blonde* plants and which, if any, are his own introductions. Thus, in Table 2, the plants recorded by Marin are separated into three categories to avoid misinterpretation.

In his checklist St. John gives dates of introductions of species whenever such dates were available.[65] These dates are included in Table 2 but are not associated with any of the other sources even if

they coincide. Degener[66] also gives dates of introduction, and his are also listed separately.

At least 111 plants are known to have been introduced during the six decades following Cook's arrival. These are enumerated in Table 2 along with the dates of record. Sixty-five are fruits, vegetables, or other economic plants, 15 may have been brought because of their ornamental value, 29 are considered "weeds," and two *(Cyperus laevigatus* and *C. javanicus)* may be indigenous.[67] It is not surprising that so many of the plants introduced during this period were food plants. As previously mentioned, seafarers often planted edibles to insure a food supply on subsequent visits. In addition, nearly all of Marin's plants were edible species.

PROBLEMATICA

Several difficulties were encountered regarding the identity of certain species and the dates of introduction of others. Among the plants which arrived aboard the *Blonde* were *Annona cherimola* and an *Annona* sp. St. John[68] lists 1825 as the date of introduction for *A. muricata* which may refer to the undetermined *Annona.* He also gives the date of introduction for *A. cherimola* as "possibly 1791," a date too early for both Marin and Vancouver. Another problem with the *Blonde* plants concerns the *Psidium* species. The common guava *(Psidium guajava)* and three other kinds of *Psidium* were brought from England. St. John lists 1825 as the introduction date for *P. cattleianum* f. *cattleianum.* One of the unidentified psidiums was called "Psidium Chinese." It is possible that this was really a variety of *P. cattleianum* which has been known horticulturally as *P. chinense.* Bloxam noted that the common guava was already in Hawai'i in 1825.[69] Degener[70] and Neal[71] credit Marin with its introduction, but it is neither mentioned in his journal nor in his correspondence.

On 22 April, 1812 Marin planted "cotton trees" in Kalihi.[72] Meyen saw cotton on Marin's Pearl Harbor estate.[73] Later, Macrae[74] and Stewart[75] both observed cotton plants in Hawai'i. St. John[76] lists four species of introduced cotton and one, the Sea Island cotton *(Cossypium barbadense),* as being introduced in 1816–1817. Because the identity of the Macrae, Stewart, Meyen, and Marin cottons cannot be verified, they are listed as *Gossypium* sp. Thus, there are two entries for cotton—*G. barbadense* and *G.* sp.

According to St. John,[77] the Isabella grape *(Vitis* x *labruscana)* was brought to Hawai'i in 1792, evidently on Vancouver's first visit.

Yee,[78] on the other hand, states that it was probably brought to Hawai'i by early Portuguese settlers from Madeira in the 1800's. "Grapes" were observed and introduced by several early visitors. Bloxam[79] brought grapes from England as well as from Rio de Janeiro aboard the *Blonde*. No mention of the Isabella grape was found, and although some may actually be the Isabella, all of the grapes have been identified as *Vitis? vinifera* in this paper.

Several plants which arrived aboard the *Blonde* are unidentifiable. The problems concerning the *Annona* and *Psidium* have already been addressed. In addition, the plum and cherries are not easily identified because of the numerous cultivated species and varieties, and there is no way of determining the *Myrtus* sp. nov. and the "several esculent seeds".

Occasionally, plants observed or collected were referred to by names too vague for proper identification. For instance, "melons" were recorded by Gaudichaud,[80] Broughton,[81] Ellis,[82] Douglas,[83] Nuttall,[84] and Marin,[85] and seeds of melons were planted by Cook's men.[86] Other unidentified plants include "calabash plants" *(? Lagenaria siceraria)* which were mentioned by Gaudichaud[87] and Douglas,[88] "mountain taro" *(? Colocasia esculenta* or *Alocasia macrorrhiza)* which were observed by Ellis,[89] "bitter gourd" which was mentioned by Macrae,[90] and "Chinese plum" which was supposedly planted by Marin on his Pauoa Valley estate.[91] "Wild tomato" was observed by Bishop.[92] Crockett[93] identifies "wild tomato" with *Solanum carolinense* L., but Krochmal[94] lists it as one of the common names for *Solanum sodomeum* L.

Four plants have been omitted from consideration because no record of them could be found in the Hawaiian literature. They are *Eugenia viridis* Berg. which was brought by the *Blonde*, *Scoparia dulcis* L. which was collected by Macrae,[95] *Euphorbia atoto* Forst. which was collected by Macrae, Nuttall, and Barclay,[96] and *Daucus* sp. *Euphorbia atoto* is a common plant in the South Pacific. It resembles many of the Hawaiian euphorbias and could have easily been misidentified. Archaeological remains of a *Daucus* were recovered from rockshelters on Mauna Kea, Hawai'i.[97] There are no native species of the genus, and besides the edible carrot, the only other *Daucus* recorded from Hawai'i is *D. pusillus*, a North American species which was considered by Hillebrand to be pre-Cook in origin.[98] The specimens, however, proved to be unlike *D. pusillus*. *Daucus* is not known from the flora of the southern Polynesian islands[99–108] and seems unlikely as an aboriginal introduction.

Table 2 gives all the dates when the post-Cook introductions were observed, collected, introduced, or planted. It must be remembered that more than one person may have brought a particular species to Hawai'i, and the dates listed are those which are available in the literature. It must also be remembered that not all the introductions survived. Many probably died soon after planting.

It seems unusual that in the six decades following Cook's arrival there are records of only about 100 plants introduced into Hawai'i, when the present flora probably includes about 5000 exotic species. Certainly, many more must have arrived during this period but were simply unnoticed. As indicated earlier, this seeming paucity of exotic species may be due in part to a bias in observation and collection. Botanists were probably more inclined to concentrate their efforts on native plants and probably chose not to collect familiar species. Early voyagers were more inclined to notice the important food plants, and travellers and residents describing native customs and the landscape would most likely be recording only the most conspicuous and widely established aboriginal and post-Cook introductions. Smaller, less conspicuous species or those found scattered in and around villages or in the forests were more apt to be overlooked.

One difficulty in dealing with observation records is the accuracy of the observer's identifications. Several of the designated botanists were not botanists by profession but physicians, horticulturists, or general naturalists. Although most were probably familiar with at least a few tropical species, not all could be considered competent in tropical botany. Sea captains and lay travellers or residents would be most likely to err, but they usually recorded the more familiar species.

SUMMARY

Thirty-two plant species of the present Hawaiian flora are believed to have been introduced during the Polynesian migrations. Although no written records exist, oral traditions relate the arrival of some of the culturally important species. The first collection and observations of these plants occurred when Cook arrived in the islands. Several were collected by David Nelson, and others were mentioned in his list and in Cook's journal. Many of the subsequent voyages recorded these aboriginal plants. Several were often recorded, but three were not documented again until after 1839.

Numerous introductions were made subsequent to Cook's arrival.

The journals of seafarers, visiting scientists, and residents, and the plant collections of botanists document the presence of at least 111 new arrivals before 1839. Most of these are edible or otherwise economic species which may have been introduced as food sources for later voyages. This review merely documents the presence of species; it is not within the scope of the study to investigate the naturalization and establishment of these species.

TABLE I

SPECIES INTRODUCED DURING THE POLYNESIAN PERIOD

Scientific Name	*Common Name*	1778–79 – Cook	1779 – Nelson	1779 – Ledyard	1786 – La Perouse	1788–89 – Meares	1792(94) – Vancouver	1792–94 – Menzies	1796 – Broughton	1809–10 – Campbell	1816 – Kotzebue	1816–17 – Chamisso	1818 – Golovnin	1819 – Gaudichaud	1822–23 – Ellis	1825 – Bloxam	1825 – Macrae	1826–27 – Lay & Collie	1830s – Bishop	1831 – Meyen	1834 – Douglas	1835–36 – Nuttall	1837 – Barclay
Aleurites moluccana*	Kukui		†							†		†		†	†	†	‡	‡		†	†	†	‡
Alocasia macrorrhiza*	'Ape																						
Artocarpus altilis	Breadfruit	†	†	†			†					†		†	†	†	†		†	†	†		
Broussonetia papyrifera	Wauke	†	†		†						†	†	†	†	†		‡†		†	†	†		
Calophyllum inophyllum	Kamani																‡						
Cocos nucifera	Coconut		†	†		†			†	†	†	†		†	†	†	†		†	†	†		
Colocasia esculenta	Taro		†	†	†	†	†			†	†	†		†	†	†	†			†	†	†	
Cordia subcordata*	Kou	†										†	†	†	†		‡	‡	†	†			‡
Cordyline terminalis	Ti									†		†		†	†	†	‡	‡	†	†	†		
Curcuma longa	'Ōlena											†		†			†			†			
Digitaria pruriens**	Kukaepua'a		‡															‡		†			
Dioscorea alata	Yam		†	†	†	†				†				†	†	†							
D. bulbifera*	Pi'oi														†								‡
D. pentaphylla*	Pi'ia																						
Eugenia malaccensis*	Mountain apple		†					‡						†		†	‡†	‡		†			
Indifiofera suffruticosa	Indigo		†																†	†			

Ludwigia octivalvis	Kāmole		†				‡					†			‡		†			‡				
Merremia aefiyptia	Hairy merremia		‡									†		‡	‡										
Morinda citrifolia*	Noni											†		‡†						‡	‡				
Musa spp.	Banana	†	†	†	†	†			†	†		†	†	†			†	†	†							
Nasturtium sarmentosum	Pa'ihi																								
Oxalis corniculata	Yellow wood sorrell		†						†			†			‡		†			‡				
Piper methysticum	'Awa	†							†			†	†		‡†	‡		†			‡	‡			
Saccharum officinarum	Sugarcane	†	†		†	†		†	†	†			†	†	†	‡	†	†	†						
Schizostachyum glaucifolium	Bamboo		†	†					†																
Tacca leontopetaloides	Pia		†								†	†		†	‡		†								
Tephrosia purpurea*	'Ahuhu											†			‡	‡		†			‡	‡			
Thespesia populnea*	Milo														‡										
Urena lobata	Aramina		†																						
Zingiber zerumbet*	'Awapuhi											†			‡			†							

LEGEND: * — Species listed by Handy and Handy as native. (Footnote 109)
** — St. John. (Footnote 110)
‡ — Collection
† — Observation

TABLE II

SPECIES INTRODUCED DURING EUROPEAN PERIOD

Scientific Name	*Common Name*	1778 – Cook	1788–89 – Meares	1792(94) – Vancouver	1792–94 – Menzies	1796 – Broughton	1809–10 – Campbell	1816–17 – Chamisso	1818 – Golovnin	1819 – Gaudichaud	1822–23 – Ellis	1825 – Bloxam	1825 – Macrae	1825 – Stewart	1826–27 – Lay & Collie	1827 – Bachelot	1830s – Bishop	1831 – Meyen	1834 – Douglas	1835–36 – Nuttall	1837–39 – Barclay	Marin: Introduced	Marin: Planted	Marin: Offserved	*fide* St. John – 1973	*fide* Degener – 1932 et seq.
Ageratum conyzoides	Ageratum												‡							‡						
Allium cepa	Onion	§							†		†												Pre 1813			
A. sativum	Garlic									†																
Amaranthus lineatus													‡													
A. viridis	Pakai								†						‡					‡						
Ananas comosus	Pineapple										†	†	†	†				†					1813		1813	
Annona cherimola	Cherimoya											§													1791?	
A. muricata	Soursop																								1825	
Armoracia rusticana	English horseradish					§																	Pre 1813			
Asparagus officinalis	Asparagus																						Pre 1813[111]			
																							1823			
Bixa orellana	Arnotto																									Early 1800
Brassica campestris	Wild mustard																†									
B. oleracea var. capitata	Cabbage					§†			†	†	†	†	†										Pre 1813[112]			
B. rapa var. rapa	Turnip									†																
Caesalpinia bondue	Kakalaioa				‡								‡		‡										1927	
C. pulcherrima	Pride of Barbados																	†							1828	
Cajanus cajan	Pigeon pea												†													
Camellia sinensis	Tea																						1818[113]			
Canna indica	Common canna												†		‡			†								
Capsicum annuum	Chili pepper									†								†					Pre 1824[114]	1812		
Cardiospermum halicacabum	Balloon vine									†					‡			†		‡					1819	

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TABLE II *(Continued)*

SPECIES INTRODUCED DURING EUROPEAN PERIOD

Scientific Name	*Common Name*	1778 – Cook	1788–89 – Meares	1792(94) – Vancouver	1792–94 – Menzies	1796 – Broughton	1809–10 – Campbell	1816–17 – Chamisso	1818 – Golovnin	1819 – Guadichaud	1822–23 – Ellis	1825 – Bloxam	1825 – Macrae	1825 – Stewart	1826–27 – Lay & Collie	1827 – Bachelot	1830s – Bishop	1831 – Meyen	1834 – Douglas	1835–36 – Nuttall	1837–39 – Barclay	Marin: Introduced	Marin: Planted	Marin: Observed	*fide* St. John – 1973	*fide* Degener – 1932 et seq.
Juglans regia	English walnut											§														
Lactuca sativa	Lettuce																						1813[120]			
Lepidium virginicum	Wild peppergrass																†									
Leucaena leucocephala	Koa haole																			‡					Post 1864	
Lythrum martimum	Pūkamole			‡			‡		†			‡		‡				†								
Macademia ternifolia var. integrifolia	Macadamia																						pre 1837		1892–4	
Malva parviflora	Small-flowered mallow												‡		‡											
Mangifera indica	Mango											§											Pre 1837		Early 1800	
Melia azedarach	Chinaberry																†									
Musa troglodytarum var. acutibracteata	He'i																						Pre 1837			
Nicotiana tabaccum	Tobacco							†		†	†	†	†	†					†				Pre 1813[121]		c.1812	
Olea europaea	Olive																					1827				
Oplismenus hirtellus	Basketgrass														‡										1841	
Opuntia megacantha	Prickly pear cactus										†							†				1818			c.1800	
Oryza sativa	Rice							†															Pre 1816[122]		1856	
Oxalis debilis var. corymbosa										†																
Persea americana	Avocado											§	‡										Pre 1837			
Petroselinum crispum	Parsley																						Pre 1813[122]		1910	
Phaseolus adenanthus				‡									‡							‡						
P. limensis	Lima bean												†[124]												Pre 1864	
P. vulgaris	Common bean																									

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APPENDIX A

Chronology of Events Significant to Hawaiian Botany

1778 First authenticated European arrival in Hawai'i—James Cook's third Pacific voyage. Touched briefly at Kaua'i and Ni'ihau. Aboard were William Anderson, surgeon and naturalist, and David Nelson, botanist. Cook's journal contains the first account of Hawaiian plant life. Pumpkins, melons, and onions were planted, the first non-Polynesian exotics in Hawai'i.

1779 Cook's second visit to the Hawaiian Islands. Visited Hawai'i, O'ahu, Kaua'i, and Ni'ihau. Nelson made the first scientific collection of plants in Hawai'i and made observations on several more during an unsuccessful ascent of Mauna Loa. Specimens sent to Sir Joseph Banks at British Museum of Natural History at Kew. Crew Member John Ledyard mentions several plants in his journal.

1786 Ill-fated French expedition consisting of 2 frigates, *Boussole* and *Astrolabe,* under the command of Capt. John Francis Galaup de la Perouse, arrived on a mission to verify previous discoveries. Arrived 29 May, departed 1 June. Only a few plants are mentioned in Perouse's log.

1788 John Meares arrived aboard the *Felice* under command of Capt. Douglas, on a fur-trading expedition to Pacific NW. Stayed in the Islands nine days and visited Hawai'i, Kaua'i, and Ni'ihau. Several plants are mentioned in Meares' journal.

1788–1789 Meares and Douglas again visited Hawai'i, on another fur-trading venture, this time aboard the *Iphigenia.* Landed at Hawai'i 6 December 1788 and visited O'ahu and Ni'ihau. Left on 8 March 1789. Visited the Islands again during July–August 1789. Meares records several plants in his journal.

1793 or 94 Don Francisco de Paula Marin arrived, perhaps as early as 1791.

1792–1794 Capt. George Vancouver, on survey mission to Pacific NW, arrived in Hawai'i 1 March 1792. Visited Hawai'i, O'ahu, Kaua'i, and Ni'ihau; left 16 March. Arrived again 12 February 1793 and surveyed the Islands, visiting Hawai'i, O'ahu, and Kaua'i. Departed for the Pacific NW 29 March. Returned January 1794; landed livestock at Kealakekua Bay and continued survey of the Islands. Departed March 1794. Archibald Menzies, botanist, made an extensive collection, successfully climbed Hualalai and Mauna Loa. Vancouver's journal mentions several plants.

1796 William Robert Broughton, abroard the sloop *Providence* during another British survey expedition to Pacific NW, arrived at Kealakekua Bay 8 January 1796. Visited Maui, O'ahu, Kaua'i, and Ni'ihau before returning to eastern Pacific in February. Stopped again in the Islands during July; visited O'ahu, Kaua'i, and Ni'ihau. Made observations on native agriculture and mentions several edible plants. Botanist on the voyage was Alexander Bishop, but no collections or notes were found.

1809–1810 English seaman Archibald Campbell arrived in January 1809 aboard Russian ship *Neva*. Resided in Hawai'i for more than a year, convalescing from a double amputation of his legs. His journal included observations on the culture and lifestyle of that period as well as several plants.

1816–1817 Lt. Otto von Kotzebue aboard the *Rurick* arrived in Hawai'i in November 1816 during the second Russian scientific expedition into the Pacific. Visited O'ahu. Stayed about a month before sailing to explore the NW coast of North America. Returned in October 1817. Botanist on the voyage, Aldebert von Chamisso, made extensive plant collections and kept a journal, but no list of collections is available, and his journal mentions only a few plants. Kotzebue's journal also mentions plants.

1818 Capt. Vassili Mikhailovitch Golovnin aboard the *Kamchatka* arrived in Hawai'i on his return trip from Alaska and Pacific NW. Visited Hawai'i, O'ahu, and Kaua'i. Several plants are mentioned in his journal.

1819 Capt. Louis Claude Desaulses de Freycinet arrived aboard the corvette *Uranie* on a French scientific expedition. Arrived at Kailua, Hawai'i 8 August 1819 and stayed less than three weeks. Visited Maui and O'ahu. Charles Gaudichaud Beaupre, botanist, spent only seven days ashore but made an extensive collection. Unfortunately, the ship was wrecked on the Falkland Islands, and half his specimens were lost. In his account of the voyage he described in great detail the vegetational ecology and phytogeography of Hawai'i.

1823 Rev. Charles Samuel Stewart arrived in Hawai'i for a residence of two years. Made observations on several introduced plants.

1823 Rev. William Ellis, in company with Messrs. Thurston, Bishop, and Goodrich, spent two months touring the island of Hawai'i. His journal of this excursion is rich with detailed observations on landscape and customs. The Rev. Charles S. Stewart was unable to accompany them due to illness.

1824–1825 Kotzebue, now Post Captain, returned to Hawai'i aboard the *Predpriatie* on another scientific voyage. Arrived in December 1824 and left 31 January 1825. Chamisso again the botanist. No journal or list of collections found.

1825 HMS *Blonde* under command of Capt. George Anson, Lord Byron was commissioned by British government to return the bodies of King Liholiho and Queen Kamamalu who died of measles in England. Aboard were James Macrae, botanist, and Andrew Bloxam, naturalist. Arrived 6 May and departed 12 July 1825. Macrae made a larger collection than any previous botanist, and kept a journal. Bloxam also kept a journal. Several live plants brought from England and Rio de Janeiro.

1826–1827 Capt. Frederick W. Beechey aboard HMS *Blossom* commanded an expedition to relieve the Parry and the Franklin expeditions which sought a NW passage through Bering Strait. Dr. George T. Lay and Alexander Collie

were the botanists. Arrived at Moloka'i 19 May 1826 and after a few days departed for Kamchatka. Only two days were spent botanizing and only 12 specimens collected. Visited the Islands again in January 1827 and collected more specimens.

1827 Sereno E. Bishop was born at Ka'awaloa, Kona Hawai'i. His father, the Rev. Artemas Bishop, arrived with the second company of American missionaries in 1823. The younger Bishop's reminiscences of his early childhood days include several plants.

1831 The Prussian world voyage under the command of Capt. W. Wendt arrived in Hawai'i. Franz F. J. F. Meyen, botanist, botanized on O'ahu for five days. He was a keen observer and mentions numerous cultivated and native plants in his journal.

1832–1834 David Douglas, sent out as a collector by London Horticultural Society, stopped briefly on O'ahu for 10 days between August and September 1832. Returned last week of 1833, went immediately to Hawai'i where he botanized until his death on 12 May 1834. Sent back many specimens, many of them ferns and mosses, to Sir Joseph Dalton Hooker at Kew.

1835–1836 Thomas Nuttall, English botanist, and John K. Townsend arrived in Hawai'i 4 January 18835. Nuttall botanized on O'ahu and Kaua'i. Left in March. Returned during winter of 1835–1836.

1836 Charles Gaudichaud returned to Hawai'i as pharmacist and botanist aboard the *La Bonite* under command of Capt. M. Vaillant. Botanized for six weeks on O'ahu, Kaua'i, and Hawai'i and made an even larger collection than on his 1819 visit. Returned to Paris to work on his collections and began to publish but stopped taxonomic work completely to pursue research in morphogenesis.

1837, 1839 HMS *Sulphur,* on a mission to survey the west coast of the Americas and fix location of certain shoals, arrived in the Islands 9 July 1837 with surgeon-naturalist Richard Brinsley Hinds and botanical collector George Barclay. Commander of the expedition, Capt. F. N. Beechey, was

replaced by Capt. Sir Edward Belcher. After staying more than a month, *Sulphur* departed for the east Pacific. On 10 June 1839 returned to Hawai'i and stayed until 16 June. Barclay's days ashore were few, but he was able to make about 90 collections, some of them exotics.

NOTES

I wish to thank Dr. Lyndon Wester, Department of Geography, University of Hawaii at Manoa, for his encouragement and advice.

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